Nutritional value of foods sold in vending machines in a UK University: formative, cross-sectional research to inform an environmental intervention

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Manuscript type: **Full length paper**

Running title: Nutrient content of vending machine foods in a UK University

Abbreviations: BMI, Body mass index; EU, European Union; FFQ, Food Frequency Questionnaire; UK, United Kingdom; WHO, World Health Organisation

Highlights

- Snacks sold by vending machines were high in sugar, fat and saturated fat
- Most beverages sold by vending machines were high in sugar
- More than half of participants (*n* 73) used vending machines at least once/week
- Vending machine users reported higher frequency of consuming savoury snacks, fruit juice, soft drinks, meat products and microwave meals, compared to non-users
- Self-reported weight status did not differ by vending machine use

Abstract

Vending machine use has been associated with low dietary quality among children but there is limited evidence on its role in food habits of University students. We aimed to examine the nutritional value of foods sold in vending machines in a UK University and conduct formative research to investigate differences in food intake and body weight by vending machine use among 137 University students. The nutrient content of snacks and beverages available at nine campus vending machines was assessed by direct observation in May 2014. Participants (mean age 22.5 years; 54% males) subsequently completed a self-administered questionnaire to assess vending machine behaviours and food intake. Self-reported weight and height were collected. Vending machine snacks were generally high in sugar, fat and saturated fat, whereas most beverages were high in sugar. Seventy three participants (53.3%) used vending machines more than once per week and 82.2% (*n* 60) of vending machine users used them to snack between meals. Vending machine accessibility was positively correlated with vending machine use (r=0.209, P=0.015). Vending machine users, compared to non-users, reported a significantly higher weekly consumption of savoury snacks (5.2 vs. 2.8, P=0.014), fruit juice (6.5 vs. 4.3, P=0.035), soft drinks (5.1 vs. 1.9, P=0.006), meat products (8.3 vs. 5.6, P=0.029) and microwave meals (2.0 vs. 1.3, P=0.020). No between-group differences were found in body weight. Most foods available from vending machines in this UK University were of low nutritional quality. In this sample of University students, vending machine users displayed several unfavourable dietary behaviours, compared to non-users. Findings can be used to inform the development of an environmental intervention that will focus on vending machines to improve dietary behaviours in University students in the UK.

Keywords: University students; vending machines; food habits; body weight; formative research

Introduction

Overweight and obesity constitute major public health issues in the United Kingdom (UK), with approximately 25% of UK adults being obese and 37% overweight (Health and Social Care Information Centre, 2014). Commencing University studies can be a challenging period for undesirable weight gain, with University students gaining an average of 2-7lbs during their first year of studies (Hoffman *et al.*, 2006; Levitsky *et al.*, 2006; Kasparek *et al.*, 2008; Racette *et al.*, 2008; Crombie *et al.*, 2009), a weight gain likely to track into adulthood (Racette *et al.*, 2008). Diets of University students are usually high in fat, sugar and salt (Soriano *et al.*, 2000; Anding *et al.*, 2001; Chourdakis *et al.*, 2011), which might contribute to the aforementioned weight gain (Brunt *et al.*, 2008; Kasparek *et al.*, 2008; Racette *et al.*, 2008), and also tend to be maintained in adulthood (Crombie *et al.*, 2009). Therefore, factors influencing food habits among University students need to be identified to prevent overweight and obesity later in life.

Several studies have recently put emphasis on the potential role of vending machines in eating behaviours and dietary quality. Foods sold in vending machines in schools, hospitals and work settings have been reported to be low in fibre and high in calories, sugar and salt (French *et al.*, 2003; Shimotsu *et al.*, 2007; Lawrence *et al.*, 2009; French *et al.*, 2010; Kibblewhite *et al.*, 2010; Kubik *et al.*, 2011; Pasch *et al.*, 2011). Vending machine behaviours, such as vending machine accessibility and use, have been positively associated with consumption of snacks (Neumark-Sztainer *et al.*, 2005; Thompson *et al.*, 2010; Minaker *et al.*, 2011; Rovner *et al.*, 2011) and soft drinks (Wiecha *et al.*, 2006; Nickelson *et al.*, 2010), although an earlier study among UK schoolchildren did not show a link between confectionery bought from vending machines and dietary quality (New & Livingstone, 2003). School vending machine availability has also been shown to affect children's lunchtime choices, with one study reporting that more children replaced lunch with vending machine snacks or beverages, when these were available (Park *et al.*, 2010). The availability of energy-dense, low-nutrient foods from vending machines (Fox *et al.*, 2009) and the presence of beverage vending machines (Minaker *et al.*, 2011) have also been associated with higher body mass index (BMI) among schoolchildren (Fox *et al.*, 2009; Minaker *et al.*, 2011).

The majority of studies examining the role of vending machine accessibility and use in dietary quality and body weight have been conducted among schoolchildren. To our knowledge, only one US study assessed the nutritional quality of vending machine foods available at campuses and reported that they were energy-dense and low in nutrients (Byrd-Bredbenner *et al.*, 2012), whereas another study showed that vending machine use was positively associated with BMI in 160 Scottish and Greek University students, although this latter association was only evident for students choosing vending machine chocolate bars (Spanos & Hankey, 2010). Seeing from the limited evidence regarding the nutrient content of foods sold in vending machines in UK Universities and the potential role of vending machines in University students' food intake and body weight, the primary aim of the current study was to assess the nutritional value of foods sold in vending machines in a UK University. The secondary aim was to conduct a cross-sectional survey to investigate differences in food intake and body weight, according to vending machine use, among a convenience sample of 137 University students. Complying with current frameworks of developing complex interventions (Craig *et al.*, 2008; World Health Organisation, 2009), findings from this study will form the formative research base on which to develop a future intervention that will aim to investigate the impact of changing the vending machine food environment on University students' dietary quality and body weight.

Materials and Methods

The snack and beverages sold in vending machines at the University of Bristol campus were assessed in May 2014 (phase 1). Subsequently (phase 2, June 2014), a cross-sectional survey was conducted among a sample of University students, who volunteered to complete a questionnaire assessing vending machine behaviours, food habits and body weight. All study procedures were approved by the Centre of Exercise, Nutrition and Health Sciences Research Ethics Committee.

Availability of vending machines and nutritional value of foods sold

A University of Bristol website search identified nine campus locations where vending machines were available, out of a total of 65 University buildings (a total of 9 vending machines). These locations consisted of four libraries, one study centre, one

cafeteria, the student's union building, and two other academic buildings and were all within walking distance of the majority of the 65 University buildings. A direct observation of the snacks and beverages sold by each vending machine was conducted by a single investigator (HP), in order to assess the variety of products sold by vending machines throughout the University and their nutritional value. A product was included in this report if it was available from at least one of the vending machines. Different flavours of the same product (e.g. crisps/potato chips) were considered as different products. Vending machines selling hot beverages (e.g. coffee, tea etc.) were excluded.

The following information was recorded from the vending machines: product name, brand (not currently reported) and container size. Front-of-pack nutritional information (grams per serving/container), when available, was recorded for fat, saturated fat, sugar and salt. When this information was not available on the product, it was obtained from the respective brand's website. To assess the nutritional value of available products, the products' front-of-pack nutritional information was compared to the UK front-of-pack nutrition labelling guidance (Department of Health, 2013). The cut-off values for a snack or beverage being considered to have a low, medium or high content in the above nutrients can be found in the footnote of Table 1.

Participants

The University of Bristol comprises approximately 12,500 undergraduate and 5,500 postgraduate students. Taking into account the short timeframe of the study, a convenience sample of University students was recruited to complete a survey for the study's second phase. Participants were approached at the café areas of two libraries and the students' study centre by the investigator (HP), who informed them of the study's aims and provided them with an information sheet. Participants had to be current students (either undergraduate or postgraduate) at the University of Bristol. All participants provided written informed consent prior to completing the study's self-administered questionnaire. All data were collected on an individual basis, with the investigator discreetly present to resolve any queries. All participants were volunteers and the questionnaire was anonymous.

Questionnaire development

A self-administered questionnaire was used to obtain data about demographic characteristics, vending machine behaviours, consumption frequency of selected food items, general food habits and body weight and height. The questionnaire required 10-15 minutes to complete.

Demographic information consisted of participants' age, sex, nationality (UK, EU, international), and status of study (full-time/part-time, undergraduate/postgraduate). The section on vending machine behaviours included six questions. Participants were asked to report how many vending machines around campus they could access in their daily routine (and in which locations), how many times per week they used vending machines ('0 days per week'/'1-2 days per week'/'≥3 days per week') and the weekly frequency (same answer categories) of buying specific snacks ('Chocolate or chocolate bars'/'Crisps (potato chips)'/'Candy bars'/'Other') and beverages ('Soft drinks'/'Diet soft drinks'/'Fruit juice'/'Water'/'Other') available from vending machines. Participants who reported using vending machines '0 days per week' were considered as 'non-users', whereas all others were categorised as 'users'. The product categories were derived based on the foods sold by vending machines around campus, as identified in phase 1 of the study. Participants were also asked to report for which eating occasions they usually use vending machines ('For meals, e.g. breakfast, lunch or dinner'/'For snacks between meals'/'Other') and their agreement with six statements (Figure 1) regarding availability of foods provided by vending machines ('Agree'/'Neutral'/'Disagree').

A previously validated food frequency questionnaire (FFQ), which has been used to assess food intake in earlier studies among University students in the UK (Papadaki & Scott, 2002; Papadaki *et al.*, 2007), was used in the current study. Participants were requested to report the number of times they consumed 23 food items per day ('>6'/'4-5'/'2-3'/'Once'), week ('5-6'/'2-4'/'Once') or month ('1-3'/'<1 or never'), namely: snacks ('sweets or chocolate', 'crisps or savoury snacks', 'cake, scones or pastries' and 'biscuits'), beverages ('fresh fruit juice', 'soft/fizzy drinks' and 'alcoholic drinks'), fruits and vegetables ('fresh fruit', 'cooked vegetables, fresh or frozen', 'raw vegetables or salad') and 'cereals', 'bread', 'potato, rice and pasta', 'beans or pulses', 'fish', 'chips', 'meat', 'meat products', 'poultry', 'milk', 'cheese',

‘yoghurt’, ‘mayonnaise, dips and sauces’. To provide an estimate of weekly food intake, it was assumed that ‘times’ could be equated to ‘servings’ (Papadaki & Scott, 2002; Papadaki *et al.*, 2007) and frequency of consumption was transformed as follows: ‘> 6 per day’ became 6 times per day, ‘4-5 times per day’ became 4.5 times per day, ‘2-3 times per day’ became 2.5 times per day etc. Daily frequency of consumption was then multiplied by seven and monthly consumption was divided by four, in order to calculate weekly food intake.

The section on general food habits consisted of questions regarding participants’ living arrangements (‘Lived at home with parents or relatives’/‘Lived alone’/‘Shared housing with friends’/‘Student residence’/‘Other’) before and since starting their studies, as well as food shopping and food preparation responsibility (‘I am’/‘Family members’/‘Others’) since starting their studies (Papadaki & Scott, 2002). Participants were also asked to report the frequency of cooking food from scratch and of consuming convenience (e.g. frozen, microwave) and take-away/fast-food meals since starting their studies (‘Every day’/‘5-6 days per week’/‘3-4 days per week’/‘1-2 days per week’/‘<1 day per week’/‘Never) and whether they perceived their eating habits (‘Yes, for the better’/‘Yes, for the worse’/‘No’/‘I don’t know’) and body weight (‘I gained weight’/‘I lost weight’/‘My weight has been stable’/‘I don’t know’) to have changed since they started their studies (Papadaki & Scott, 2002). For ease of interpretation and analysis, ‘Living arrangements’ was collapsed into ‘Living with family’ and ‘Living away from family’, whereas ‘Food shopping’ and ‘Food preparation responsibility’ were collapsed into ‘I am (responsible)’ and ‘Other people (are responsible)’. Frequency of consuming home-cooked, convenience and take-away meals was transformed in a similar manner to the FFQ (i.e. ‘5-6 days per week’ became 5.5 days per week and so on).

Self-reported weight and height data were collected and body mass index (BMI) was calculated as weight divided by height squared (kg/m^2). Body weight status was determined according to standards suggested by WHO (World Health Organisation, 2000). A copy of the questionnaire is available from the corresponding author.

Statistical analysis

Data were analysed using the SPSS software (IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp). Descriptive statistics (means, standard deviations and frequencies) were used to explore demographic characteristics, vending machine behaviours, general food habits and body weight. As continuous variables did not have a normal distribution, the non-parametric Mann-Whitney U test and Chi-square tests were used to investigate any differences between vending machine users and non-users in continuous and categorical variables, respectively. Spearman's correlations were used to examine associations between vending machine accessibility and vending machine use.

Results

Nutrient content of foods from vending machines

Four types of snack products, namely crisps, chocolate bars, candy (e.g. jellies, liquorice, taffy, gums) and flapjacks (a dense sweet cake made from oats, golden syrup, and melted butter), were available throughout the University vending machines. Of these, there were 11 varieties of crisps, 18 varieties of chocolate bars, four varieties of other candy and three varieties of flapjacks. Thus, of the 36 total varieties of snack products available, the majority were chocolate bars (50%), followed by crisps (30.6%), candy (11.1%) and flapjacks (8.3%). In addition, five types of drinks were available (fruit juice, regular soft drinks, diet soft drinks, energy drinks and water). Of these, there were three varieties of soft drinks, one variety of diet soft drink, four varieties of fruit juice, three varieties of energy drinks and one variety of water. Fruit juice was the main type of drink offered (41.7% of the total 12 varieties of drinks available), followed by soft drinks (25%), energy drinks (25%) and water (8.3%). Front-of-pack labelling for sugar, fat, saturated fat and salt was available for 23% of snacks and 100% of drinks. The nutrient content of snacks and beverages, namely sugar (g), fat (g), saturated fat (g) and salt (g), is presented in Table 1.

Compared with the UK front-of-pack nutrition labelling guidance (Department of Health, 2013), the majority of available snacks had a high total fat, saturated fat and sugar content (80.6%, 61.1% and 69.4%, respectively), while 11.1% of snacks had a high salt content. All chocolate bars and flapjacks had a high content of saturated fat

and sugar, and 88.9% of chocolate bars had a high content of total fat. All candy had a high sugar content. Of the crisps available, 90.9% were high in total fat and 27.3% were high in salt. Most of the drinks (75%) contained high levels of sugar.

➔ **TABLE 1**

Participants

Table 2 demonstrates the sample's demographic and personal characteristics. A total of 137 students (54% males, mean age 22.5 years, BMI 22.2 kg/m^2) completed the questionnaire. The majority of participants were normal-weight, undergraduate, British or international students, who lived away from their families since commencing their studies and for whom food shopping and preparation before starting their studies had been performed by family members. More than half of participants (*n* 73, 53.3%) used vending machines at least once a week and were considered as vending machine users. There were no differences in sex, nationality, age or living arrangements between vending machine users and non-users, but more vending machine users had their food shopped for by family members before commencing their studies, compared to non-users (80.8 vs. 66.1%, *P*=0.034).

➔ **TABLE 2**

Vending machine behaviours

Of the nine vending machines available, participants accessed (were exposed to) an average of 2 (SD 1.3, range 0-8) vending machines in their daily routine. Vending machine accessibility was positively correlated with vending machine use (*r*=0.209, *P*=0.015). Table 3 demonstrates vending machine users' reported behaviours regarding vending machine use. All vending machine users consumed at least one vending machine product at least 1-2 days per week. Vending machine users used vending machines to buy chocolate bars and crisps more frequently than other snacks, and water and regular soft drinks more frequently than other drinks. The vast majority of vending machine users (*n* 60, 82.2%) used vending machines to snack between meals.

➔ **TABLE 3**

Figure 1 illustrates the differing attitudes towards food available in vending machines. The majority of participants (*n* 96, 70% and *n* 95, 69%) agreed that vending machines

should have healthy snack and drink options, respectively. Almost half of participants (*n* 70, 51%) thought that food available in vending machines was expensive and 40% (*n* 55) reported that they found the variety of available foods to be limited. As expected, vending machine users were more likely than non-users to agree with the statement 'I do not have any problems finding food I need from campus vending machines' (49.3% vs. 18.8%, *P*=0.002).

➔ **FIGURE 1**

Food intake

The consumption of different foods (servings/week) in the total study sample and among vending machine users and non-users is shown in Table 4. Vending machine users, compared to non-users, had a significantly higher weekly consumption of savoury snacks (5.2 vs. 2.8, *P*=0.014), fruit juice (6.5 vs. 4.3, *P*=0.035), soft drinks (5.1 vs. 1.9, *P*=0.006), meat products (8.3 vs. 5.6, *P*=0.029), poultry (6.0 vs. 3.7, *P*=0.001), fish (3.2 vs. 1.8, *P*=0.013) and microwave meals (2.0 vs. 1.3 times/week, *P*=0.020). Only 30% (*n* 41) of participants cooked food from scratch on a daily basis, whereas almost half of the participants consumed microwave/frozen meals (*n* 68) and take-away meals (*n* 65) at least one day/week.

➔ **TABLE 4**

Perceived changes since starting University

The majority of participants (*n* 100, 73%) perceived that their eating habits had changed since starting their studies at the University but 44.5% (*n* 61) perceived their body weight to have been stable (Table 5). No differences were found between vending machine users and non-users, as well as between different BMI groups, in perceived changes in body weight and eating habits since starting University. In addition, there were no differences in self-reported BMI between vending machine users and non-users (*P*=0.440).

➔ **TABLE 5**

Discussion

The current study aimed to assess the nutritional value of foods sold in vending machines in a UK University and conduct a formative, cross-sectional survey to investigate differences in food intake and body weight among a convenience sample

of University students who are vending machine users and non-users. To our knowledge, this is the first study to present a combined examination of these constructs in a sample of University students. We found that most snacks sold by vending machines were high in sugar, fat and saturated fat, whereas most beverages were high in sugar. More than half of participants used vending machines at least once per week, with vending machine users displaying several unfavourable dietary behaviours, compared to non-users. Body weight did not differ according to vending machine use.

The types of foods and drinks sold in vending machines at this University were limited, with only four types of snacks and five types of drinks being available. Chocolate bars and crisps were the main type of snacks offered, whereas soft drinks and energy drinks, when combined, constituted half of the drinks sold. When assessed according to the Department of Health's guidance (Department of Health, 2013), the majority of vending machine foods and drinks were of low nutritional quality. Most drinks, including fruit juice, were high in sugar, while chocolate bars and flapjacks were high in sugar, fat and saturated fat. In addition, candy products had high levels of sugar and crisps had high levels of fat. These findings are in agreement with recent studies examining the nutritional content of foods sold in vending machines at University (Byrd-Bredbenner *et al.*, 2012), healthcare (Lawrence *et al.*, 2009; Kibblewhite *et al.*, 2010) and recreational (Chaumette *et al.*, 2009; Naylor *et al.*, 2010) settings, confirming the poor nutritional quality of foods and limited number of options that are lower in sugar, fat and saturated fat available by vending machines. In the current study, nutritional labelling of foods available in vending machines was also often inadequate, since 77% of foods sold did not provide information on the sugar, fat and saturated fat content in the front of their pack. In addition, front-of-pack labelling was not always visible at point of purchase and some products labelled to be 'healthy options' (e.g. fruit juices) were actually high in sugar. Currently, nutrition labelling of packaged foods is highly recommended, albeit voluntary, in the UK (Grunert & Wills, 2007) and 63% of products in the UK market provide front-of-pack labelling information (Storcksdieck Genannt Bonsmann *et al.*, 2010). In contrast, a recent US regulation makes calorie labelling of foods sold in vending machines mandatory (Food and Drug Administration, 2014). Our findings emphasise the need for the European Council to implement policies for all foods sold in vending machines

to have front-of-pack labelling and for foods to be displayed in ways that allow labelling to be visible, in order to facilitate consumers who use food labels in making informed choices. Our recent research among 524 students from 37 UK Universities showed that 63.7% of the sample were frequent label users (reading nutrition labels 'often' or 'always or almost always' (Cooke & Papadaki, 2014), suggesting that making front-of-pack labelling mandatory might play an important role in food choice, at least for individuals who actually read the labels.

Over half of the study sample (53.3%) were vending machine users, which is in agreement with earlier research in University students (Caruso *et al.*, 2014), and vending machine accessibility was positively associated with vending machine use. This agrees with three earlier studies, which showed that the number of available vending machines was positively related to vending machine use among adolescents (Neumark-Sztainer *et al.*, 2005; Park *et al.*, 2010; Minaker *et al.*, 2011). Thus, our finding supports the notion that the presence of vending machines might play a role in students' vending machine use and provides additional evidence to endorse the need for Universities to implement policies regarding the nutritional content of foods sold in vending machines.

The majority of participants thought that vending machines should have healthy food and drink options available, which is consistent with a recent qualitative study examining perceptions of University students regarding promotion of healthy foods from vending machines (Ali *et al.*, 2015), and that the variety of food available was limited. Nevertheless, more vending machine users, compared to non-users, reported that they did not have problems finding the foods they need from vending machines, suggesting a higher level of satisfaction with the food and drink options available among these participants. This might imply that the availability of healthier options might not influence the purchase of foods with lower nutritional content that are high in fat and sugar, as were currently offered by vending machines at this University. This is supported by a recent study among US University students, which showed that students preferred to buy less healthful snacks from vending machines, despite the availability of healthier options and the indication with green colour labelling that these should be preferred most often (Caruso *et al.*, 2014).

Vending machine users displayed several unfavourable dietary behaviours, compared to non-users. Specifically, they reported a higher weekly consumption of savoury snacks, fruit juice and soft drinks. This is in support of earlier research among US school children and adolescents, which showed that vending machine users were more likely to have a higher intake of regular soft drinks and chocolate (Thompson *et al.*, 2010), as well as a study in US middle school students, which showed that students who used vending machines had an increased likelihood of consuming soft drinks (Nickelson *et al.*, 2010). Even though the vast majority of vending machine users used vending machines to snack between meals, our study also showed that vending machine users had a higher intake of meat products and microwave meals, which adds to Thompson *et al*'s (2010) finding that students who used vending machines had a higher consumption of fast foods. This indicates that vending machine use might influence general eating habits, in addition to snacking behaviours, or that poor eating habits might cluster within individuals. Nevertheless, and similar to an earlier study (New & Livingstone, 2003), no difference in fruit and vegetable intake was found between vending machine users and non-users. More research is needed to establish whether vending machine use is associated with, or can influence food intake during other eating occasions, in addition to snacking.

Similar to earlier research in University students (Papadaki & Scott, 2002), approximately 30% of participants reported that they had gained weight since starting their studies. Nevertheless, there were no differences between vending machine users and non-users in perceived changes in body weight or self-reported BMI. In addition, we did not observe any associations between BMI and vending machine use, and BMI was not related to the choice of specific foods from vending machines. This is in contrast to earlier studies. For example, research has shown positive associations between BMI and buying chocolate bars from vending machines in University students (Spanos & Hankey, 2010), between the presence of vending machines selling beverages in schools and weight status among Canadian adolescents (Minaker *et al.*, 2011) and between the availability of low-nutrient, energy-dense foods in vending machines and BMI z-scores among middle school US students (Fox *et al.*, 2009). The discrepancy between our findings and this earlier research might stem from the higher proportion of normal-weight participants in our sample, whereas none of the participants in the current study were classified as obese, compared to these earlier

studies (e.g. more than 20% of participants in the study by Fox *et al.* were obese). Ideally, future studies should attempt to recruit participants with a wider BMI range to examine such associations and differences, and also investigate the potential role that the length of time since starting University might play on BMI and/or perceived body weight changes.

The current study has certain weaknesses that limit the external validity of the findings. We were only able to assess the nutrient content of vending machines available at the main campus, as identified via the University of Bristol website. Future studies should ideally conduct a more detailed evaluation of all vending machines that University students might access. Nevertheless, participants did not report accessing other vending machines that might be present at other University premises (e.g. student residences), and all the nine locations of the assessed vending machines were within walking distance of the majority of all University buildings, therefore providing a valuable measure of what was accessible to students.

Participants in the formative, cross-sectional survey were a self-selected group of volunteers, and the vast majority were of normal weight, which might hinder the generalisibility of the results due to the potential of self-selection bias. The size of this convenience sample was also small, which was necessitated by the study's timeframe and the labour-intensive assessment of vending machine products' nutrient content, which was the study's primary aim, and might also have been due to the cross-sectional survey being conducted in June, a busy month for students due to examinations. This limits our ability to generalise the findings to the whole student population of the University of Bristol. Nevertheless, our sample covered a relatively wide range of students with regards to sex, age, nationality and graduate status, thus providing us with an indication of behaviours in students with different characteristics. The self-reported food frequency questionnaire used has been utilised to assess the dietary behaviours of University students in earlier research (Papadaki & Scott, 2002; Papadaki *et al.*, 2007) but might have been prone to recall-bias, as well as over-reporting of foods that are considered healthy and under-reporting of items considered unhealthy, particularly when combined with social desirability bias (Podsakoff *et al.*, 2003). The original questionnaire (Papadaki & Scott, 2002; Papadaki *et al.*, 2007) did not distinguish between regular and diet soft drinks and we

decided to not change that in the current study, particularly seeing from the recent systematic reviews indicating an increased, albeit tenuous, risk of type 2 diabetes with consumption of artificially sweetened soft drinks (Greenwood *et al.*, 2014; Imamura *et al.*, 2015). The fact that the 'times' a food was consumed was equated to 'portions' might have underestimated the reporting of food intake if a participant consumed more than one portions each time a food was consumed, but this would have likely affected both groups (vending machine users and non-users) consistently (Papadaki *et al.*, 2007). Despite their limitations, food frequency questionnaires are commonly used in epidemiological studies (Shim *et al.*, 2014). Although self-reported BMI can be underestimated (Merrill & Richardson, 2009), it can be used to estimate overweight and obesity in epidemiological studies (Spencer *et al.*, 2002; Fonseca *et al.*, 2010). We also relied on self-reported data to assess vending machine use, as more objective measures (e.g. product sales information obtained by vending machine operators) would not have allowed us to link this information to participating students, since vending machines are also accessible to University staff. In addition, by asking participants to report their weekly use of vending machines, we might not have captured those who might be vending machine users on a less frequent basis (e.g. once, or a few times per month).

Establishing the decision-making regarding how and where products are displayed in vending machines was beyond the scope of this study. However, future studies should ideally obtain this information from vending machine operators and campus food services before developing policies to promote vending machine changes. Finally, the cross-sectional study design does not allow any causative inferences to be made. As Minaker and colleagues note (Minaker *et al.*, 2011), a longitudinal study design would have been able to capture the effect of vending machine availability and use on dietary behaviours and body weight.

Despite these limitations, this study is the first, to our knowledge, to assess the nutrient content of foods sold in vending machines in a UK University. Another strength of this study is that it forms a formative research base, which, according to current frameworks of developing behaviour change interventions (Craig *et al.*, 2008; World Health Organisation, 2009), should be built prior to designing an intervention. As such, these findings can be used to inform the development of interventions to

change the vending machine food environment and inform policies regarding foods available from vending machines at UK Universities. Our findings also make a useful contribution to the limited evidence base (Spanos & Hankey, 2010) on the relationship between actual vending machine use (as opposed to presence of vending machines) and body weight. Thus, the current study provides the rationale for future research into the role of vending machines in the food habits and body weight of University students in the UK.

Conclusion

The nutritional quality of the majority of foods and drinks available from vending machines in this UK University was poor. In this convenience sample of University students, vending machine users generally had more unfavourable dietary behaviours, compared to non-users, but no differences in body weight were found according to vending machine use. Findings from the current formative research study can be used to inform the development of an environmental intervention that will focus on vending machines to improve food habits in University students in the UK.

Conflicts of interest statement

The authors have no conflicts of interest.

The study received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

References

Ali HI, Jarrar AH, Abo-El-Enen M, Shamsi MA & Ashqar HA (2015) Students' perspectives on promoting healthful food choices from campus vending machines: a qualitative interview study. *BMC Public Health* 15, 512.

Anding J, Suminski R & Boss L (2001) Dietary intake, body mass index, exercise, and alcohol: are college women following the dietary guidelines for Americans? *J Am Coll Health* 49, 167-171.

Brunt A, Rhee Y & Zhong L (2008) Differences in dietary patterns among college students according to body mass index. *J Am Coll Health* 56, 629-634.

Byrd-Bredbenner C, Johnson M, Quick V, Walsh J, Greene G, Hoerr S, Colby S, Kattelmann K, Phillips B, Kidd T & Horacek T (2012) Sweet and salty. An assessment of the snacks and beverages sold in vending machines on US post-secondary institution campuses. *Appetite* 58, 1143-1151.

Caruso M, Klein E & Kaye G (2014) Campus-Based Snack Food Vending Consumption. *J Nutr Educ Beh* 46, 401-405.

Chaumette P, Morency S, Royer A, Lemieux S & Tremblay A (2009) Food environment in the sports, recreational and cultural facilities of Quebec City: a look at the situation. *Can J Public Health* 100, 310-314.

Chourdakis M, Tzellos T, Pourzitaki C, Toulis K, Papazisis G & Kouvelas D (2011) Evaluation of dietary habits and assessment of cardiovascular disease risk factors among Greek university students. *Appetite* 57, 377-383.

Cooke R & Papadaki A (2014) Nutrition label use mediates the positive relationship between nutrition knowledge and attitudes towards healthy eating with dietary quality among university students in the UK. *Appetite* 83, 297-303.

Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I & Petticrew M (2008) Developing and evaluating complex interventions: the new Medical Research Council guidance. *BMJ* 337, a1655.

Crombie A, Ilich J, Dutton G, Panton L & Abood D (2009) The freshman weight gain phenomenon revisited. *Ann Rev Nutr* 67, 83-94.

Department of Health (2013) Guide to creating a front of pack (FoP) nutrition label for pre-packed products sold through retail outlets. Available at: https://**www.gov.uk/government/publications/front-of-pack-nutrition-labelling-guidance**. Accessed: 21st March 2015.

Fonseca H, Silva AM, Matos MG, Esteves I, Costa P, Guerra A & Gomes-Pedro J (2010) Validity of BMI based on self-reported weight and height in adolescents. *Acta Paediatr* 99, 83-88.

Food and Drug Administration (2014) Food labeling: calorie labeling of articles of food sold in vending machines. Available at: https://www.federalregister.gov/articles/2014/12/01/2014-27834/food-labeling-calorie-labeling-of-articles-of-food-in-vending-machines. Accessed: 29th September 2015.

Fox MK, Dodd AH, Wilson A & Gleason PM (2009) Association between school food environment and practices and body mass index of US public school children. *J Am Diet Assoc* 109, S108-117.

French SA, Hannan PJ, Harnack LJ, Mitchell NR, Toomey TL & Gerlach A (2010) Pricing and availability intervention in vending machines at four bus garages. *J Occup Environ Med* 52, S29-33.

French SA, Story M, Fulkerson JA & Gerlach AF (2003) Food environment in secondary schools. A la carte, vending machines and food policies and practices. *Am J Public Health* 93, 1161-1167.

Greenwood DC, Threapleton DE, Evans CEL, Cleghorn CL, Nykjaer C, Woodhead C & Burley VJ (2014) Association between sugar-sweetened and artificially sweetened soft drinks and type 2 diabetes: systematic review and dose–response meta-analysis of prospective studies. *Br J Nutr* 112, 725-734.

Grunert KG & Wills JM (2007) A review of European research on consumer response to nutrition information on food labels. *Journal of Public Health* 15, 385-399.

Health and Social Care Information Centre (2014) Statistics on obesity, physical activity and diet: England 2014. Available at: **http://www.hscic.gov.uk/catalogue/PUB13648/Obes-phys-acti-diet-eng-2014-rep.pdf**. Accessed: 21st March 2015.

Hoffman D, Policastro P, Quick V & Lee SK (2006) Changes in body weight and fat mass of men and women in the first year of college: a study of the 'Freshman 15'. *J Am Coll Health* 55, 41-45.

Imamura F, O'Connor L, Ye Z, Mursu J, Hayashino Y, Bhupathiraju SN & Forouhi NG (2015) Consumption of sugar sweetened beverages, artificially sweetened beverages, and fruit juice and incidence of type 2 diabetes: systematic review, meta-analysis, and estimation of population attributable fraction *BMJ* 351, h3576.

Kasparek D, Corwin S, Valois R, Sargent R & Morris R (2008) Selected health behaviors that influence college freshman weight change. *J Am Coll Health* 56, 437-444.
Kibblewhite S, Bowker S & Jenkins HR (2010) Vending machines in hospitals - are they healthy? *Nutr Food Sci* 40, 26-28.
Kubik MY, Lytle LA & Farbakhsh K (2011) School and district wellness councils and availability of low-nutrient, energy dense vending fare in Minnesota middle and high schools. *J Am Diet Assoc* 111, 150-155.
Lawrence S, Boyle M, Craypo L & Samuels S (2009) The food and beverage vending environment in health care facilities participating in the healthy eating,active communities program. *Pediatrics* 123, S287-292.
Levitsky D, Garay J, Nausbaum M, Neighbors L & Dellavalle D (2006) Monitoring weight daily blocks the freshman weight gain: a model for combating the epidemic of obesity. *Int J Obes* 30, 1003-1010.
Merrill RM & Richardson JS (2009) Validity of self-reported height, weight, and body mass index: findings from the National Health and Nutrition Examination Survey, 2001-2006. *Prev Chronic Dis* 6, A121.
Minaker LM, Storey KE, Raine KD, Spence JC, Forbes LE, Plotnikoff RC & McCargar LJ (2011) Associations between the perceived presence of vending machines and food and beverage logos in schools and adolescents' diet and weight status. *Public Health Nutr* 14, 1350-1356.
Naylor P, Bridgewater L, Purcell M, Ostry A & Vander-Wekken S (2010) Publicly funded recreation facilities: obesogenic environments for children and families? *Int J Environ Res Public Health* 7, 2208-2221.
Neumark-Sztainer D, French SA, Hannan PJ, Story M & Fulkerson JA (2005) School lunch and snacking patterns among high school students: associations with school food environment and policies. *Int J Behav Nutr Phys Act* 2, 14.
New SA & Livingstone MB (2003) An investigation of the association between vending machine confectionery purchase frequency by schoolchildren in the UK and other dietary and lifestyle factors. *Public Health Nutr* 6, 497-504.
Nickelson J, Roseman MG & Forthofer MS (2010) Associations between parental limits, school vending machine purchases, and soft drink consumption among Kentucky middle school students. *J Nutr Educ Beh* 42, 115-122.

Papadaki A, Hondros G, Scott JA & Kapsokefalou M (2007) Eating habits of University students living at, or away from home in Greece. *Appetite* 49, 169-176.
Papadaki A & Scott JA (2002) The impact on eating habits of temporary translocation from a Mediterranean to a Northern European environment. *Eur J Clin Nutr* 56, 455-461.
Park S, Sappenfield WM, Huang Y, Sherry B & Bensyl DM (2010) The impact of the availability of school vending machines on eating behavior during lunch: the Youth Physical Activity and Nutrition Survey. *J Am Diet Assoc* 110, 1532-1536.
Pasch K, Lytle L, Samuelson A, Farbakhsh K, Kubik M & Patnode C (2011) Are school vending machines loaded with calories and fat. An assessment of 106 middle and high schools. *J School Health* 81, 212-218.
Podsakoff PM, Mackenzie SB, Lee JY & Podsakoff NP (2003) Common method biases in behavioral research: a critical review of the literature and recommended remedies. *J App Psychol* 88, 879-903.
Racette S, Deusinger S, Strube M, Highstein G & Deusinger R (2008) Changes in weight and health behaviors from freshman through senior year of college. *J Nutr Educ Beh* 40, 39-42.
Rovner AJ, Nansel TR, Wang J & Iannotti RJ (2011) Food sold in school vending machines is associated with overall student dietary intake. *J Adolesc Health* 48, 13-19.
Shim JS, Oh K & Kim HC (2014) Dietary assessment methods in epidemiologic studies. *Epidemiol Health* 36, e2014009.
Shimotsu ST, French SA, Gerlach AF & Hannan PJ (2007) Worksite environment physical activity and healthy food choices. Measurement of the worksite food and physical activity environment at four metropolitan bus garages. *Int J Behav Nutr Phys Act* 4, 17.
Soriano JM, Molto JC & Manes J (2000) Dietary intake and food pattern among university students. *Nutr Res* 20, 1249-1258.
Spanos D & Hankey CR (2010) The habitual meal and snacking patterns of university students in two countries and their use of vending machines. *J Hum Nutr Diet* 23, 102-107.
Spencer EA, Appleby PN, Davey GK & Key TJ (2002) Validity of self-reported height and weight in 4808 EPIC-Oxford participants. *Public Health Nutr* 5, 561-565.

Storcksdieck Genannt Bonsmann S, Celemín LF, Larrañaga A, Egger S, Wills JM, Hodgkins C & Raats MM (2010) Penetration of nutrition information on food labels across the EU-27 plus Turkey. *Eur J Clin Nutr* 64, 1379-1385.

Thompson OM, Yaroch AL, Moser RP, Finney Rutten LJ & Agurs-Collins T (2010) School vending machine purchasing behavior: results from the 2005 Youth Styles survey. *J School Health* 80, 225-232.

Wiecha JL, Finkelstein D, Troped PJ, Fragala M & Peterson KE (2006) School vending machine use and fast-food restaurant use are associated with sugar-sweetened beverage intake in youth. *J Am Diet Assoc* 106, 1624-1630.

World Health Organisation (2000) Obesity: Preventing and managing the global epidemic. *WHO Technical Report Series 894,* 1-253.

World Health Organisation (2009) Interventions on diet and physical activity: what works: summary report. Geneva: WHO

Table 1. Front-of-pack nutritional value (grams/serving) of snacks and beverages sold in vending machines

	Sugar [a]	Fat [b]	Saturated fat [c]	Salt [d]
Snacks				
Crisps/potato chips (mean of 11 varieties)	2.8	25.6	3.5	1.60
Chocolate bars (mean of 18 varieties)	52.3	25.2	14.8	0.28
Other candy (e.g. (e.g. jellies, liquorice, taffy, gums) (mean of 4 varieties)	79.8	3.9	2.2	0.02
Flapjack (dense sweet cake made from oats, golden syrup, and melted butter) (mean of 3 varieties)	21.8	21.1	10.3	0.04
Beverages				
Soft drinks (mean of 3 varieties, excluding diet drinks)	10.9	0.0	0.0	0.00
Fruit juice (mean of 4 varieties)	8.5	0.0	0.0	0.00
Energy drinks (mean of 3 varieties)	9.1	0.0	0.0	0.00
Water (mean of 1 variety)	0.0	0.0	0.0	0.00

Black, grey and white shadings indicates a high, medium and low nutrient content, respectively, as compared with the UK front-of-pack nutrition labelling guidance (Department of Health, 2013)

[a] For snacks, the cut-off values for sugar were: low (≤5.0g/100g), medium (5.1-22.5g/100g) and high (>22.5g/100g or >27g/portion). For beverages, the cut-off values for sugar were: low (≤2.5g/100ml), medium (2.6-11.25g/100ml) and high (>11.3g/100ml or >13.5g/portion).

[b] For snacks, the cut-off values for fat were: low (≤3.0g/100g), medium (3.1-17.5g/100g) and high (>17.5g/100g or >21g/portion). For beverages, the cut-off values for fat were: low (≤1.5g/100ml), medium (1.6-8.75g/100ml) and high (>8.75g/100ml or >10.5g/portion).

[c] For snacks, the cut-off values for saturated fat were: low (≤1.5g/100g), medium (1.6-5.0g/100g) and high (>5.0g/100g or >6.0g/portion). For beverages, the cut-off values for saturated fat were: low (≤0.75g/100ml), medium (0.76-2.5g/100ml) and high (>2.5g/100ml or >3g/portion).

[d] For snacks, the cut-off values for salt were: low (≤0.3g/100g), medium (0.4-1.5g/100g) and high (>1.5g/100g or >1.8g/portion). For beverages, the cut-off values for salt were: low (≤0.3g/100ml), medium (0.4-0.75g/100ml) and high (>0.75g/100ml or >0.9g/portion).

Table 2. Sample characteristics

Characteristic	***n***	**Percentage (%)**
Sex, *n* 137		
Male	74	54.0
Female	63	46.0
Age (years), *n* 137		
18-21	66	48.2
22-25	51	37.2
≥26	20	14.6
BMI (kg/m^2), *n* 126		
Normal weight (18.5-25.0)	110	88.3
Overweight (25.1-29.9)	16	11.7
Obese (≥30)	0	0.0
Nationality, *n* 137		
UK	61	44.5
EU	17	12.4
International	59	43.1
Graduate status, *n* 137		
Undergraduate, 1st year	17	12.4
Undergraduate, 2nd year	34	24.8
Undergraduate, 3rd year	34	24.8
Postgraduate	52	38.0
Living arrangements (before University), *n* 137		
Living with family	103	75.1
Living away from family	34	24.9
Living arrangements (after University), *n* 137		
Living with family	11	8.1
Living away from family	126	91.9
Food shopping responsibility (before University), *n* 137		
I am	37	27.0
Family members	100	73.0
Food preparation responsibility (before University), *n* 137		
I am	31	22.6

Family members	106	77.4
Frequency of vending machine use, *n* 137		
0 days/week	64	46.7
1-2 days/week	56	40.9
≥3 days/week	17	12.4

BMI, body mass index; UK, United Kingdom; EU, European Union

Table 3. Vending machine behaviours of vending machine users (*n* 73)

Vending machine behaviour	***n***	**Percentage (%)**
Frequency of buying crisps from vending machines		
0 days/week	43	58.9
1-2 days/week	27	37.0
≥3 days/week	3	4.1
Frequency of buying chocolate bars from vending machines		
0 days/week	32	43.8
1-2 days/week	38	52.1
≥3 days/week	3	4.1
Frequency of buying candy bars from vending machines		
0 days/week	69	94.5
1-2 days/week	4	5.5
≥3 days/week	0	0.0
Frequency of buying flapjacks from vending machines		
0 days/week	70	95.9
1-2 days/week	3	4.1
≥3 days/week	0	0.0
Frequency of buying regular soft drinks from vending machines		
0 days/week	48	65.7
1-2 days/week	23	31.5
≥3 days/week	2	2.7
Frequency of buying diet soft drinks from vending machines		
0 days/week	59	80.9
1-2 days/week	9	12.3
≥3 days/week	5	6.8
Frequency of buying fruit juice from vending machines		
0 days/week	58	79.5
1-2 days/week	13	17.8
≥3 days/week	2	2.7
Frequency of buying energy drinks from vending machines		
0 days/week	72	98.6
1-2 days/week	1	1.4

≥3 days/week	0	0.0
Frequency of buying water from vending machines		
0 days/week	40	54.8
1-2 days/week	24	32.9
≥3 days/week	9	12.3
Reason for using vending machines		
To eat as a main meal	5	6.8
To snack between meals	60	82.2
To quench thirst	8	11.0

Table 4. Consumption of foods (servings/week) and types of meals in the study sample (*n* 137) and among vending machine users and non-users

Food (servings/week)	**Total (n = 137) Mean (SD)**	**Vending machine users (n = 73) Mean (SD)**	**Vending machine non-users (n = 64) Mean (SD)**	***P*-value**
Cereals	6.5 (7.3)	6.6 (7.6)	6.3 (6.9)	0.653
Fresh fruit	12.8 (9.9)	11.7 (8.9)	13.9 (10.9)	0.505
Cooked vegetables	10.5 (8.1)	10.5 (7.9)	10.5 (8.3)	0.990
Raw vegetables	7.2 (7.9)	7.3 (7.4)	7.0 (8.4)	0.326
Bread	8.7 (9.1)	9.6 (10.3)	7.8 (7.4)	0.416
Chips	2.8 (4.6)	2.8 (3.9)	2.8 (5.3)	0.122
Potatoes, rice, pasta	8.8 (8.5)	9.5 (9.1)	8.1 (7.6)	0.618
Meat	10.1 (9.3)	11.3 (10.1)	8.7 (8.2)	0.088
Meat products	7.0 (7.5)	8.3 (7.9)	5.6 (6.8)	0.029
Poultry	4.9 (5.7)	6.0 (5.9)	3.7 (5.3)	0.001
Fish	2.6 (2.8)	3.2 (3.4)	1.8 (1.6)	0.013
Milk	8.1 (7.5)	8.3 (7.7)	7.9 (7.4)	0.400
Cheese	4.4 (4.9)	4.6 (5.3)	4.2 (4.6)	0.573
Yogurt	3.4 (5.2)	3.5 (5.5)	3.2 (4.9)	0.589
Beans/ pulses	2.6 (3.1)	2.7 (3.4)	2.5 (2.7)	0.631
Sweets, sugar, chocolate	6.6 (8.4)	6.9 (9.2)	6.2 (7.4)	0.790
Crisps/ savoury snacks	4.1 (6.5)	5.2 (8.1)	2.8 (3.6)	0.014
Fresh fruit juice	5.4 (6.8)	6.5 (7.8)	4.3 (5.1)	0.035
Soft/ fizzy drinks	3.6 (6.6)	5.1 (8.4)	1.9 (2.9)	0.006
Alcoholic drinks	3.4 (4.9)	3.9 (6.1)	2.8 (3.0)	0.597
Mayonnaise, dips, sauces	3.4 (5.7)	3.8 (5.2)	3.0 (6.2)	0.080
Biscuits	3.4 (5.7)	3.7 (6.6)	3.2 (4.7)	0.727
Cakes, pastries, scones	2.5 (3.8)	2.9 (4.8)	2.0 (2.0)	0.640
Types of meals (times/week)				
Homemade food[a]	4.6 (2.3)	4.3 (2.4)	4.9 (2.2)	0.127
Microwave/frozen meals	1.7 (1.9)	2.0 (2.2)	1.3 (1.6)	0.020
Take-away/fast-food meals	1.4 (1.5)	1.5 (1.5)	1.4 (1.6)	0.669

Differences between vending machine users and non-users were examined using the Mann-Whitney test.

[a] Homemade food was defined as food students cooked from scratch

Table 5. Perceived changes in body weight and eating habits of the study sample (*n* 137) and among vending machine users and non-users since starting University

	Total (n = 137) ***n*** **(%)**	**Vending machine users (n = 73)** ***n*** **(%)**	**Vending machine non-users (n = 64)** ***n*** **(%)**	***P*-value**
Body weight changed				0.226
Weight gain	38 (27.7)	22 (30.1)	16 (25.0)	
Weight loss	27 (19.7)	14 (19.2)	13 (20.3)	
Weight has been stable	61 (44.5)	28 (38.4)	33 (51.6)	
Do not know	8 (5.8)	9 (12.3)	2 (3.2)	
Eating habits changed				0.482
For the better	47 (34.3)	22 (30.1)	25 (39.1)	
For the worse	53 (38.7)	31 (42.5)	22 (34.4)	
No changes	27 (19.7)	16 (21.9)	11 (17.2)	
Do not know	10 (7.3)	4 (5.5)	6 (9.4)	

Differences between vending machine users and non-users were examined using the Chi-Square test.

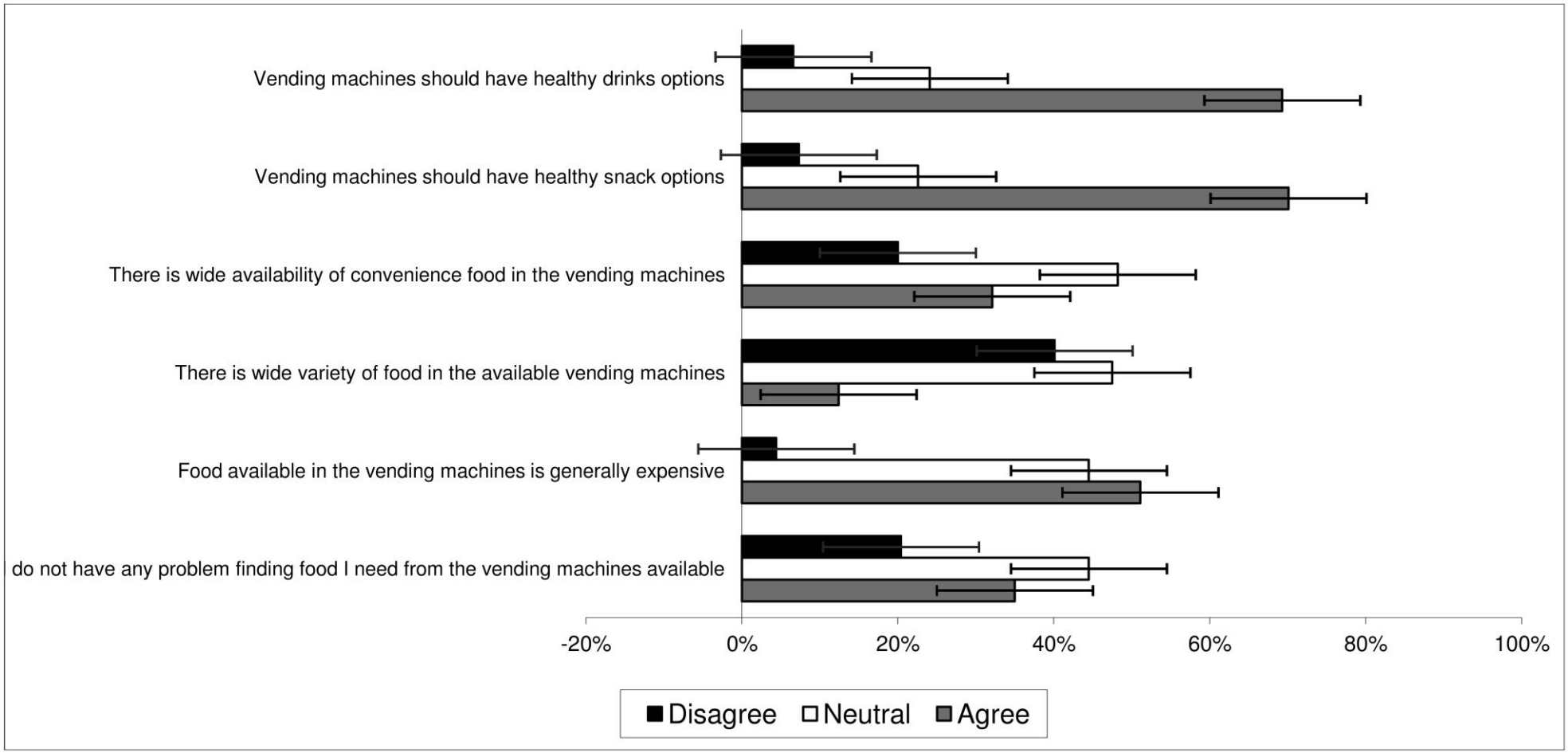
Figure Legends

Figure 1 Attitudes of participants regarding availability of food by vending machines (*n* 137)

Footnote to Figure 1:

'Healthy snack options' were defined as options that were lower in sugar, fat, saturated fat and/or salt and 'healthy drinks options' were defined as options that were lower in sugar, according to the UK front-of-pack nutrition labelling guidance (Department of Health, 2013).

1


Vending machines should have healthy drinks options
Vending machines should have healthy snack options
There is wide availability of convenience food in the vending machines
There is wide variety of food in the available vending machines
Food available in the vending machines is generally expensive
do not have any problem finding food I need from the vending machines available
-20%
0%
20%
40%
60%
80%
100%
Disagree
Neutral
Agree

2